# Impacts of past land use on spatial heterogeneity of soil nutrients in Southern Appalachian forests

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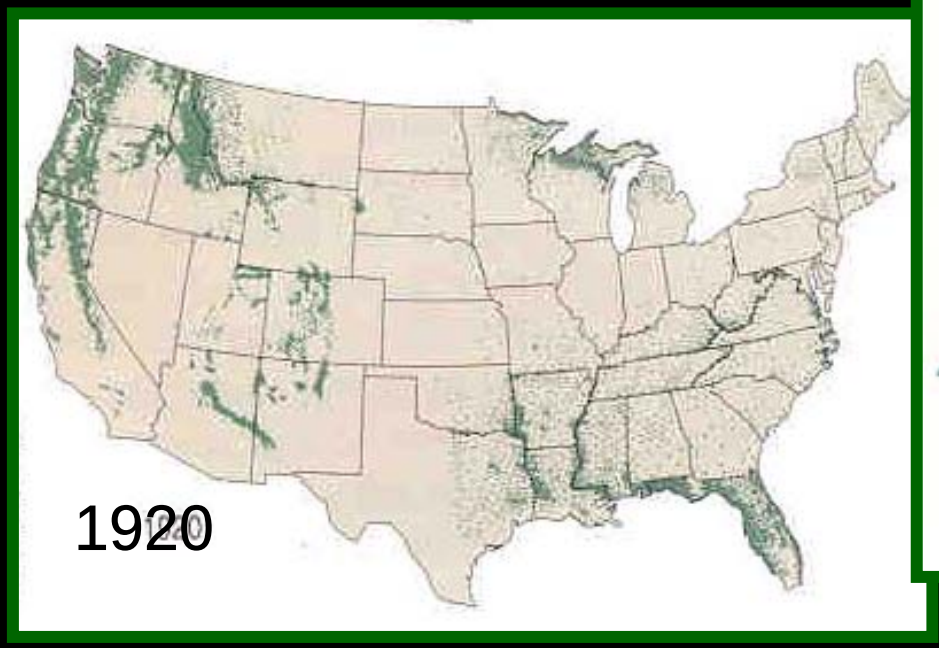
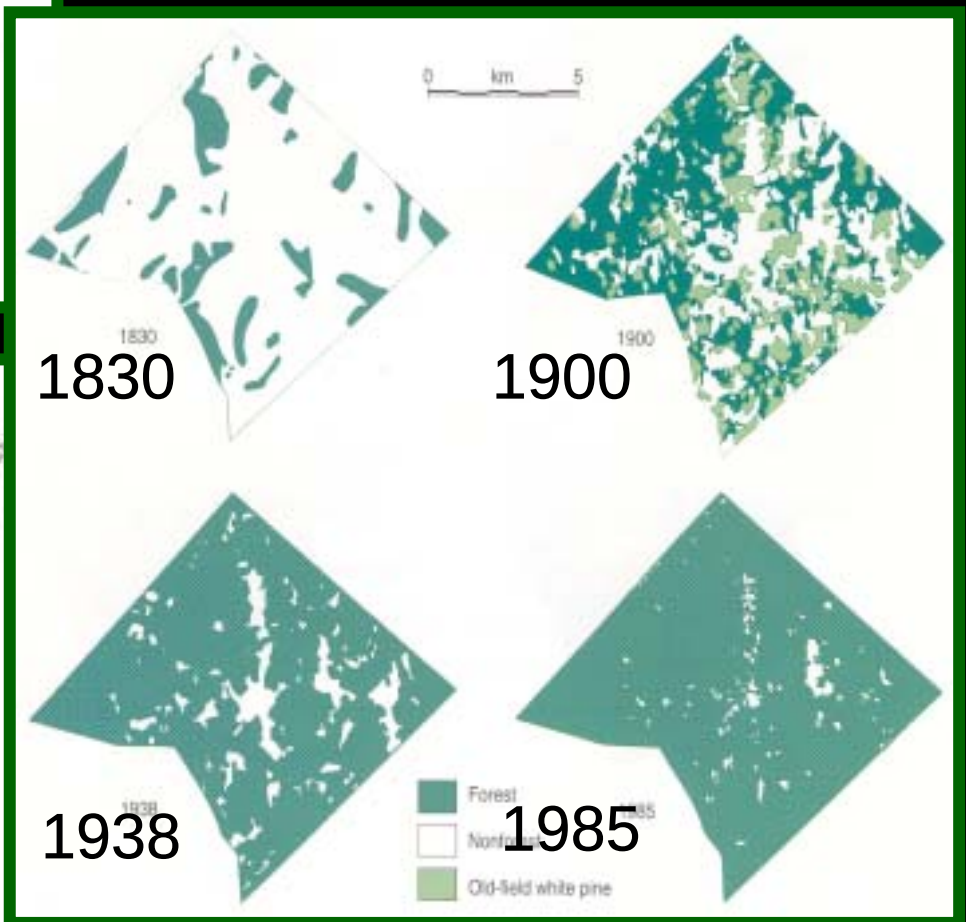
# Land-Use Change: North America


Turner et al. 1998

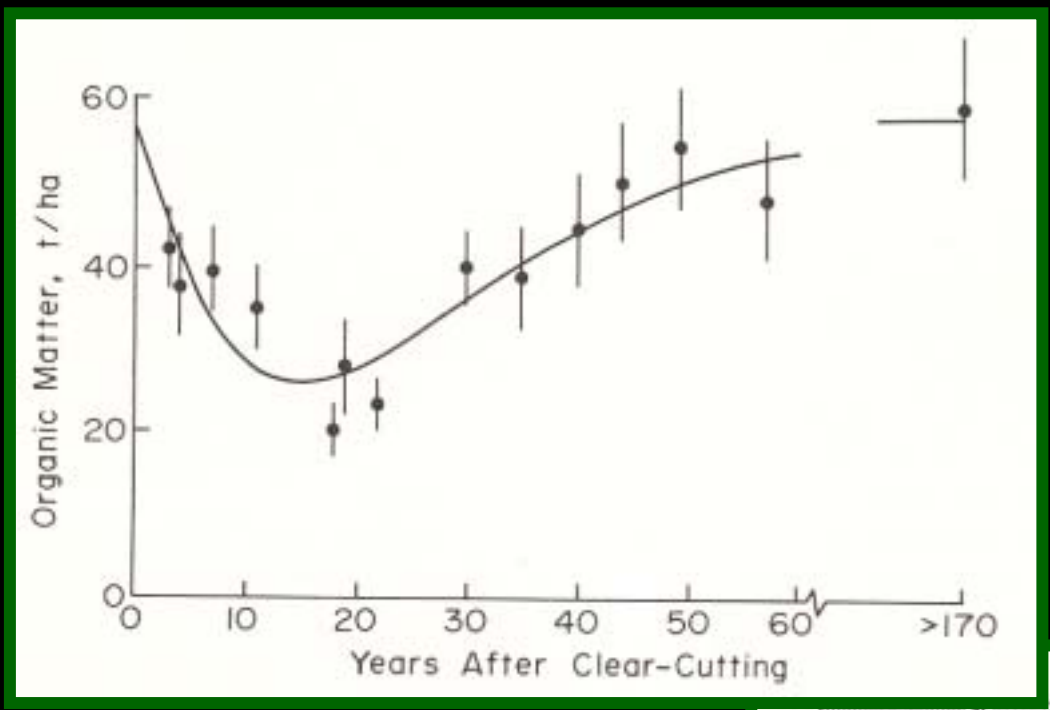
# Historic Land Use in the Southern Appalachian Highlands

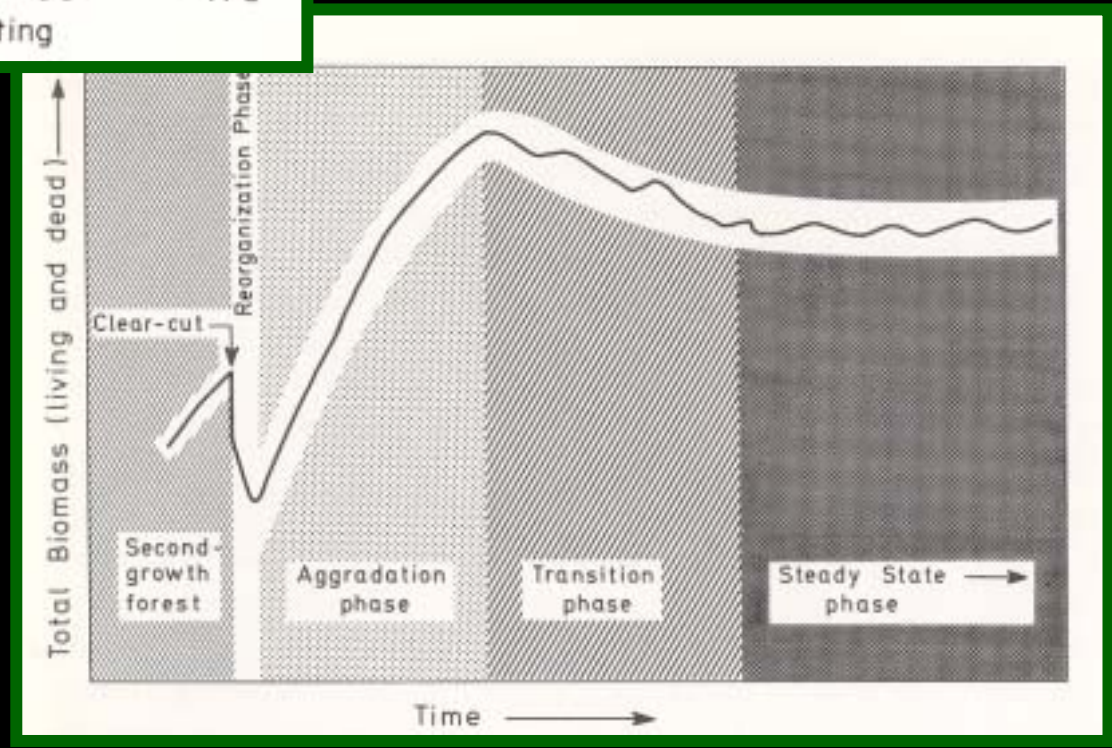
Yarnell 1998

# Presentation Outline

1. Paradigms of ecosystem recovery from disturbance
2. Forest soil as an index of recovery
3. Introduction to the study
4. Legacies of past land use
5. Some hypotheses
6. Links to future work and climate change impacts

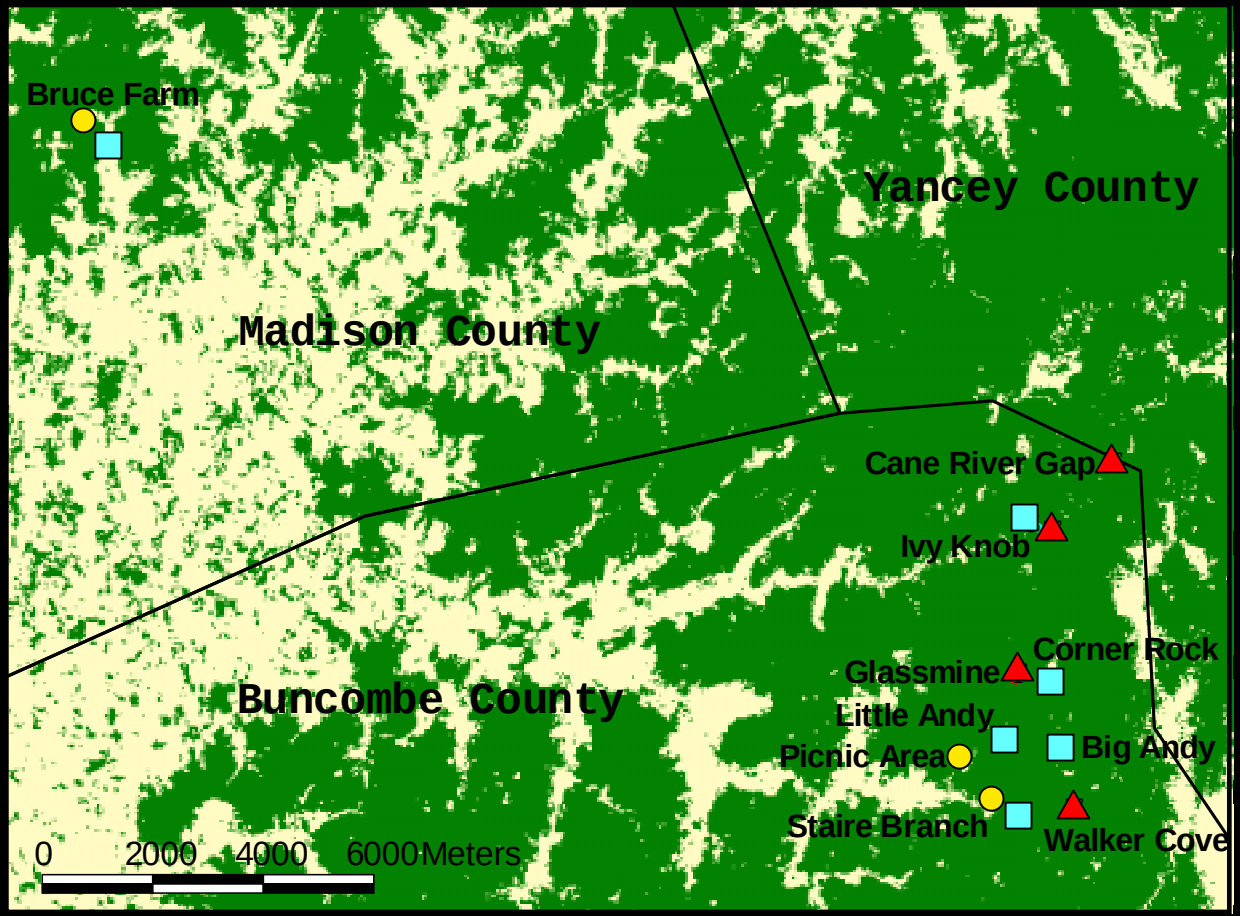
# Paradigms of Ecosystem Recovery from Hubbard Brook



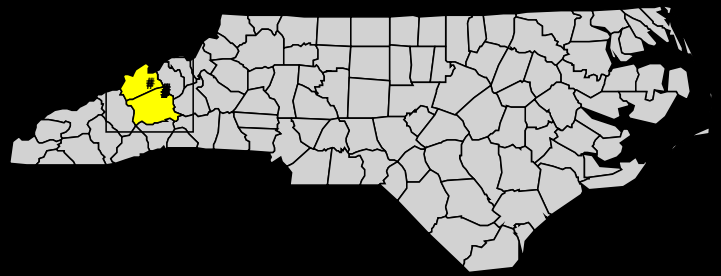




Bormann and Likens 1979

# Southern Appalachian Highlands







**Pasturing**
trees and stumps removed, forage grasses seeded, cattle and sheep grazing

**Logging**
trees removed, no burning

**Reference**
no physical signs of anthropogenic disturbance

# Forest Soils: Index of Recovery

Forest soils

- often disturbed by former land-use practices
- long memory (e.g., plow layer)
- realm of many important forest ecosystem functions

Responses of interest (nutrient pools and turnover)

- mean concentration (g/kg), content (g/ha)
- variability
- spatial patterns of distribution

# Research Questions

1. How does prior land use influence the variability of soil nutrients and the scale at which that variability is expressed?

2. Do historic land-use practices alter the spatial structure of fine-scale patterns in soil resources?

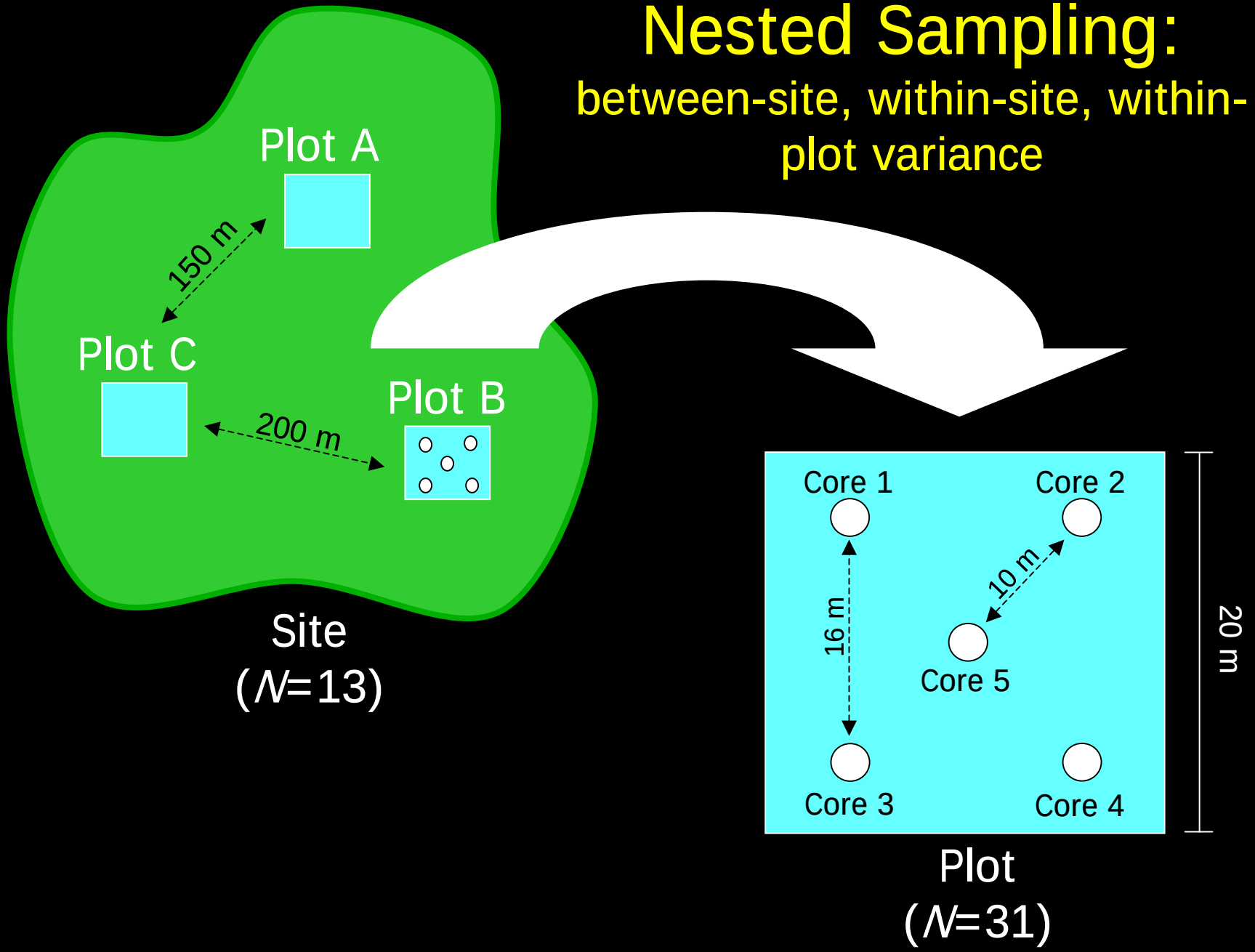
# Sampling Strategy

- Collected the upper 15 cm of mineral soil ($N$=674 cores) in 2001 and 2002

- Employed standard laboratory methods to determine nutrient concentration and content

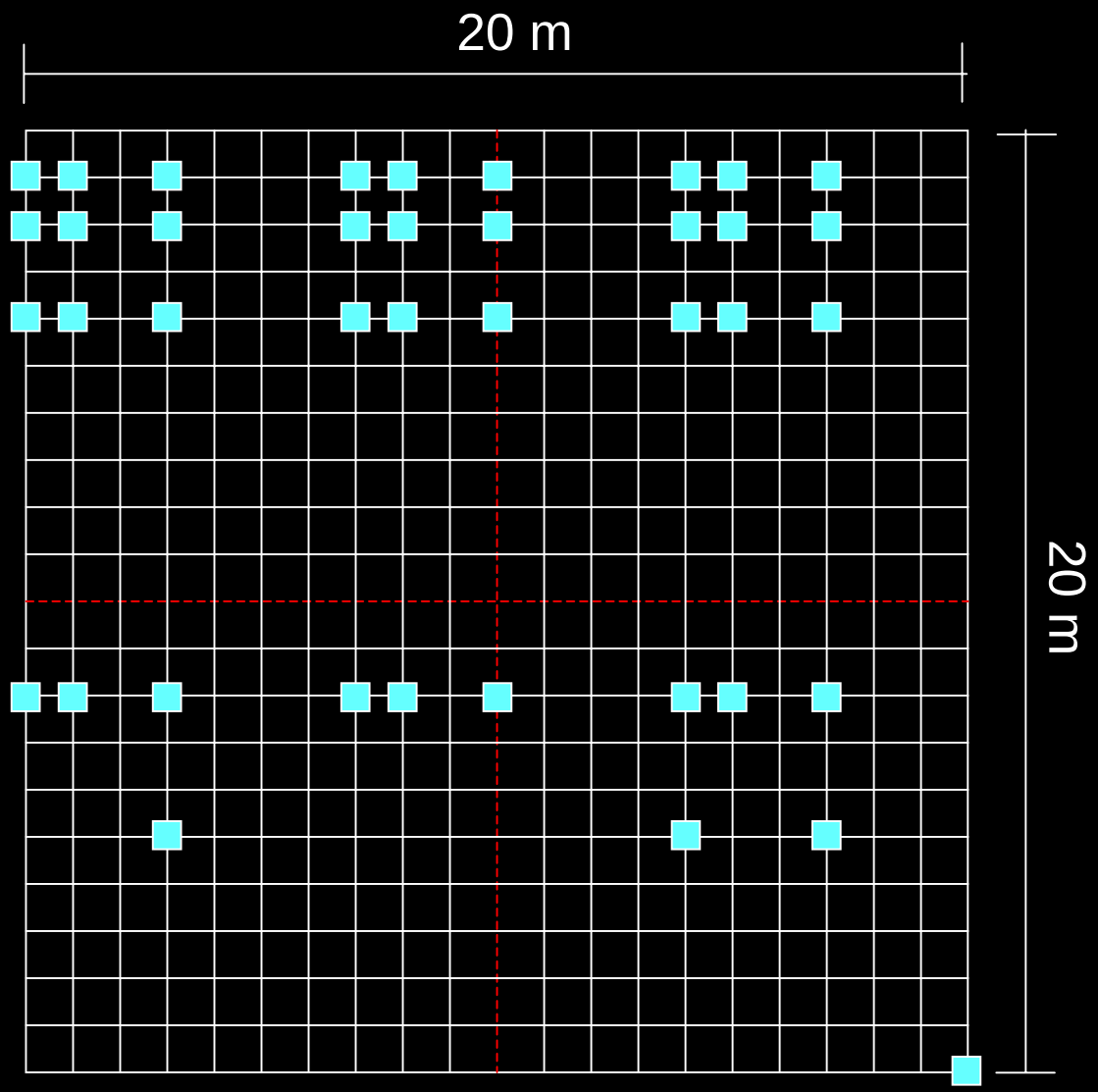
# Nested Sampling:

## between-site, within-site, within-plot variance

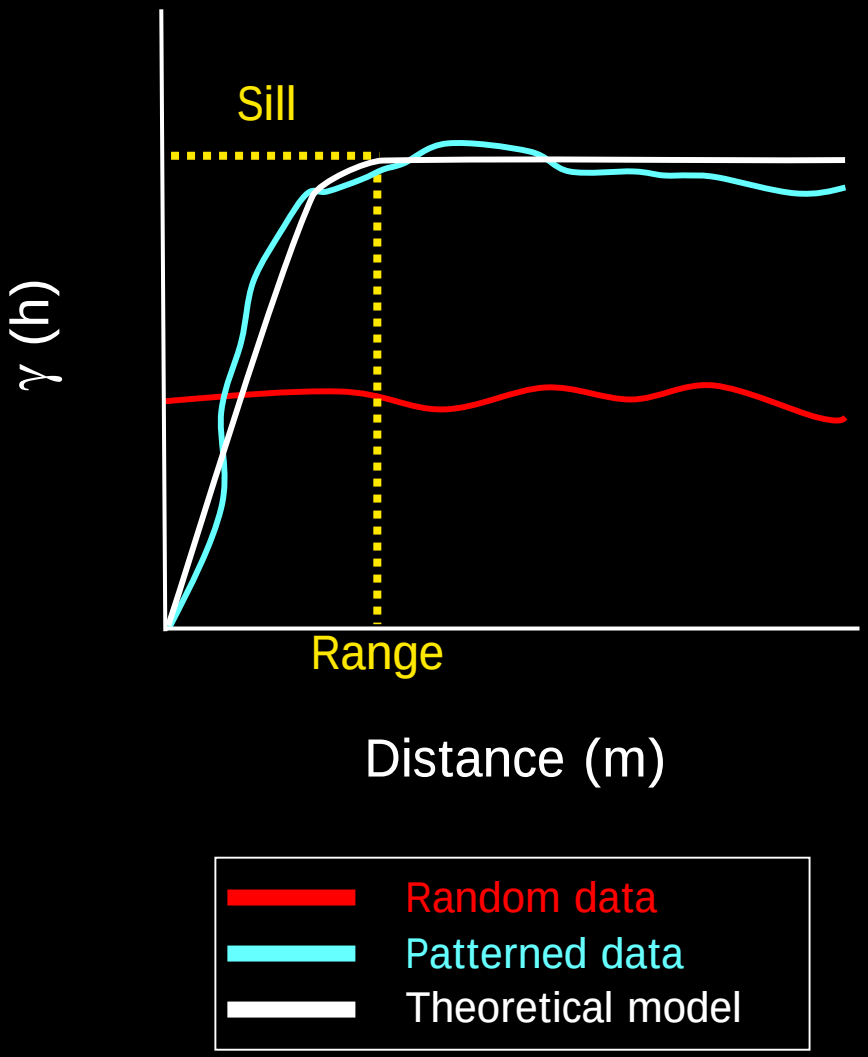


# Spatially Explicit Sampling

9 plots (3 of each LU type)



# Semi-variograms



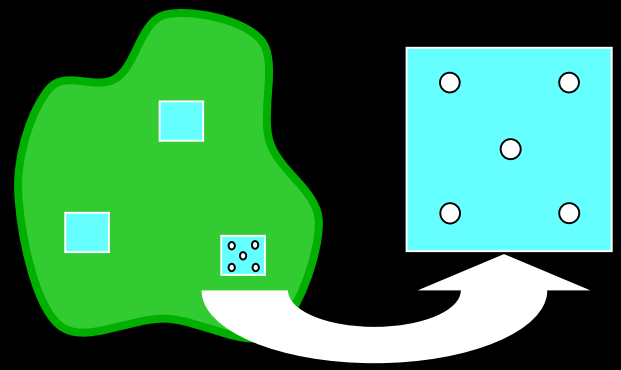

- Summarize the variance for different lag distances (h) among a set of points in 1- or 2-D space

$$\gamma(h) = \frac{1}{2N(h)} \sum_{i=1}^{N(h)} [z(x_i) - z(x_i + h)]^2$$

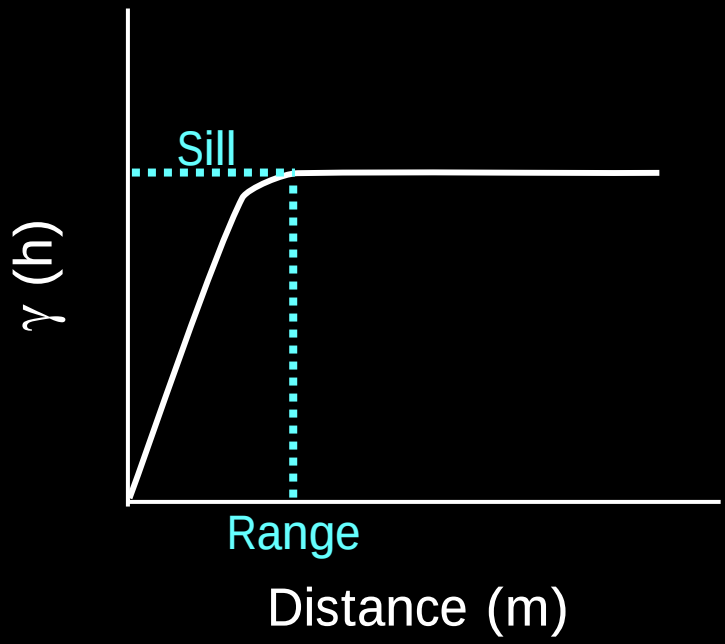
- Theoretical models can be fit to curves to estimate parameters (e.g., sill, range)

# Statistical Analysis

- Estimated variance components at 3 scales (between-site, within-site, within-plot)

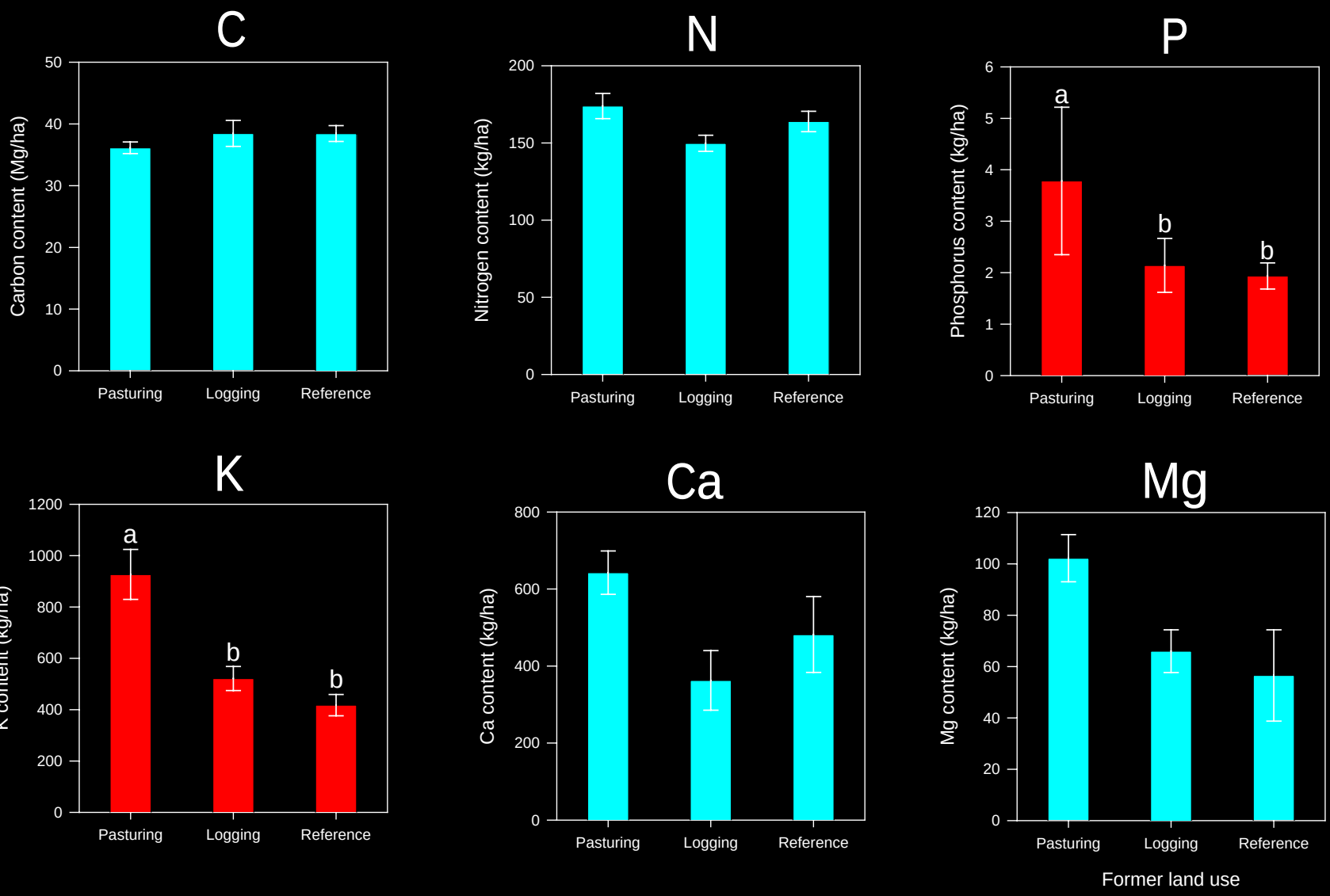


- Constructed semi-variograms and fit the spherical model




- Compared model parameters for each land-use pair using a one-tailed Wilcoxon two-sample test

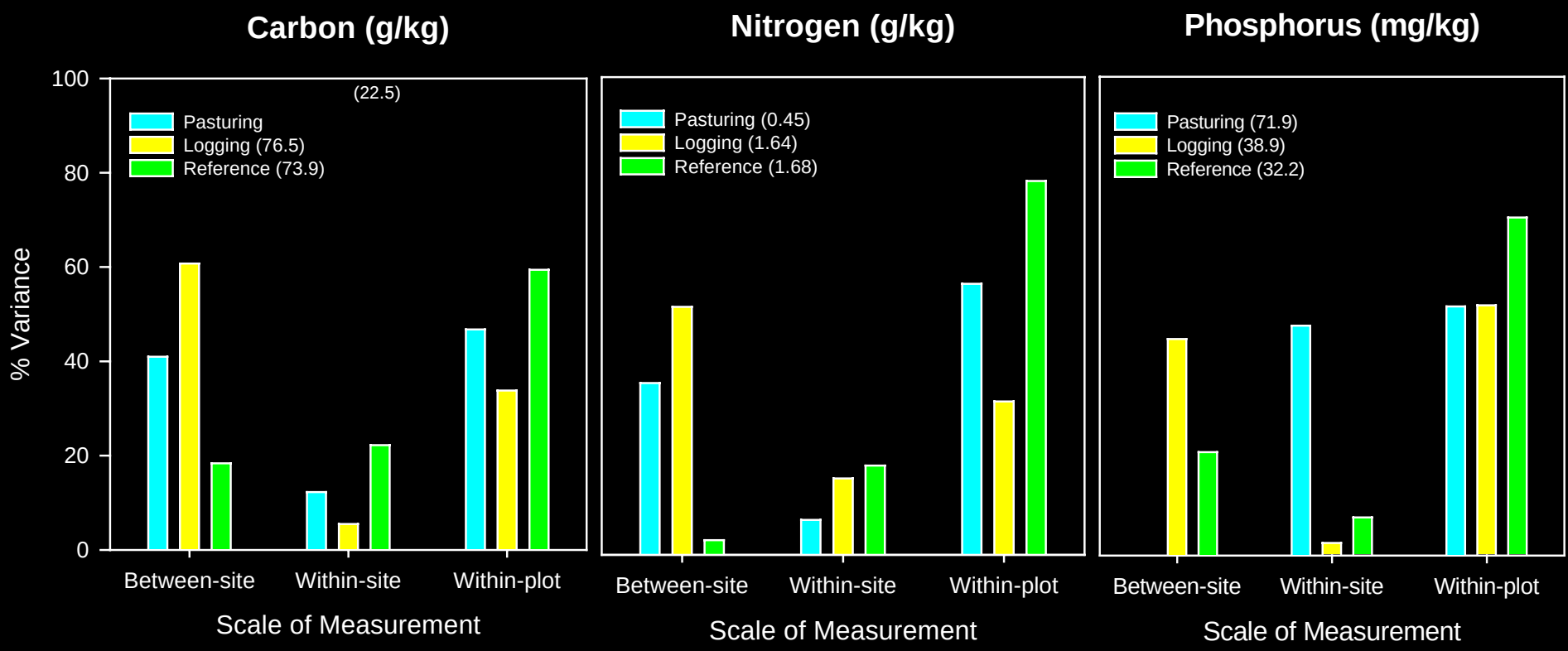
# Mean Soil Nutrient Content

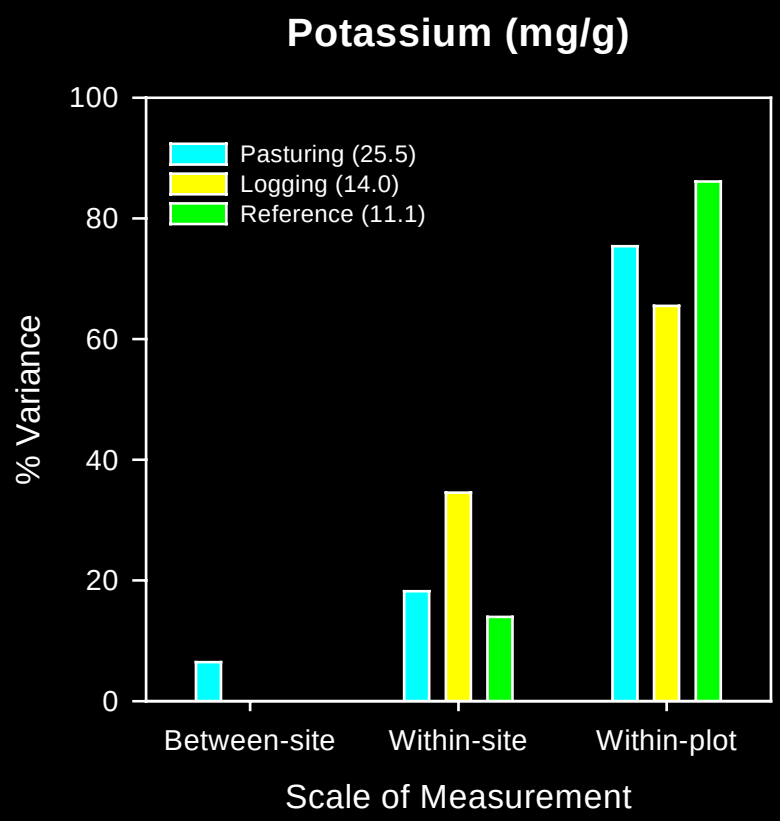


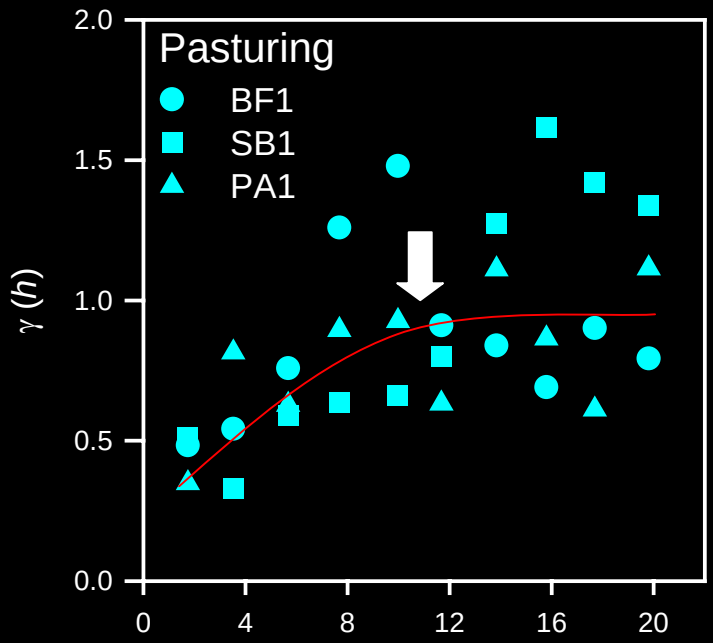
# Total Variance

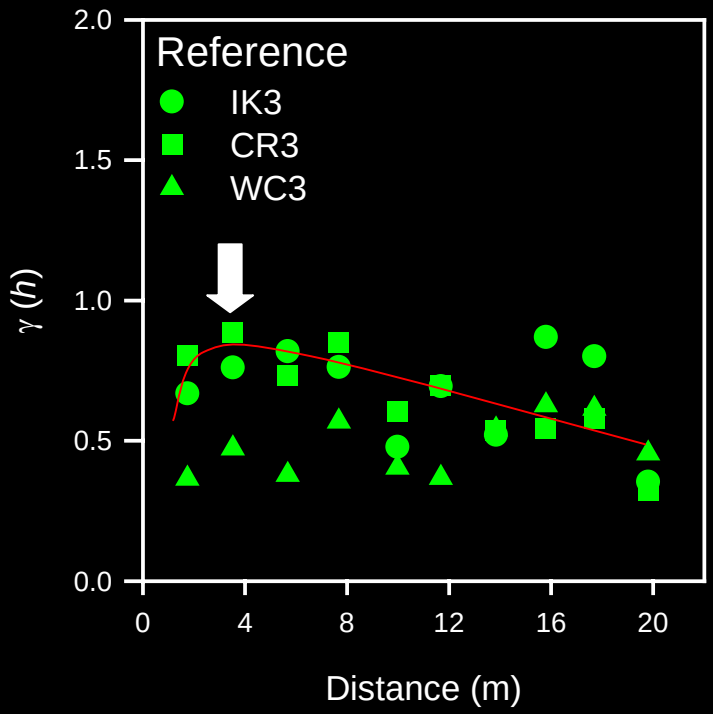
| | Pasturing | Logging | Reference |
|---|---|---|---|
| C (g/kg) | 22.5 | 76.5 | 73.9 |
| N (g/kg) | 0.45 | 1.64 | 1.68 |
| Ca (mg/kg) | 29.9 | 33.8 | 54.8 |
| P (mg/kg) | 71.9 | 38.9 | 32.2 |
| K (mg/g) | 25.5 | 14.0 | 11.1 |
| Mg (mg/g) | 0.50 | 0.45 | 0.31 |

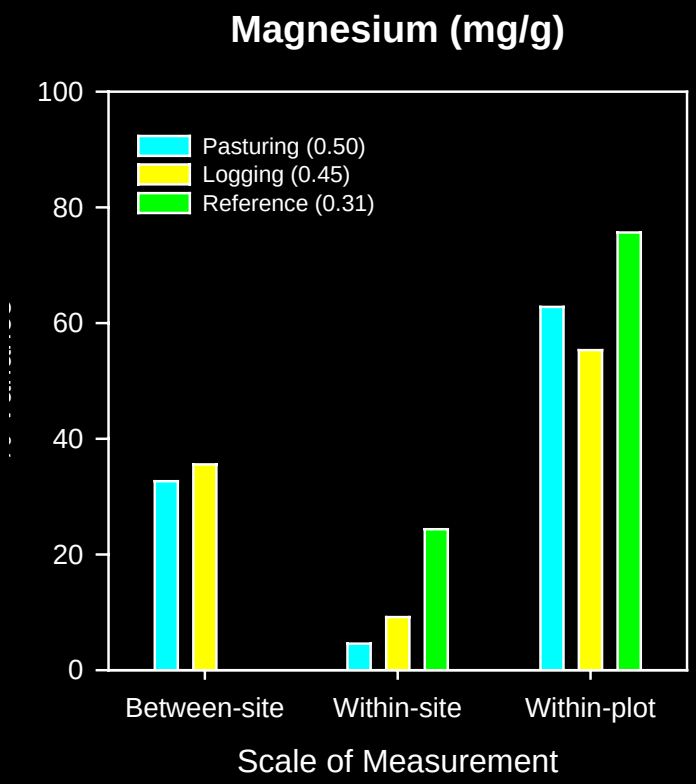
# Variance At Multiple Scales: C, N and P

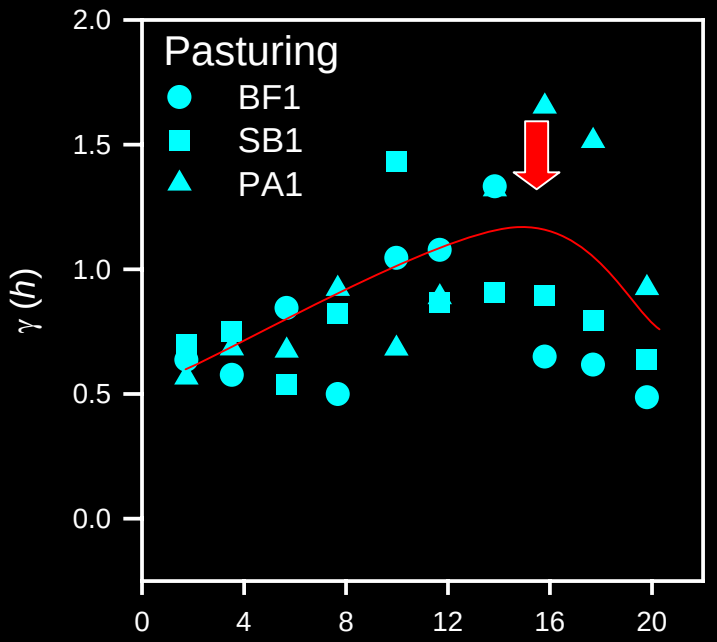


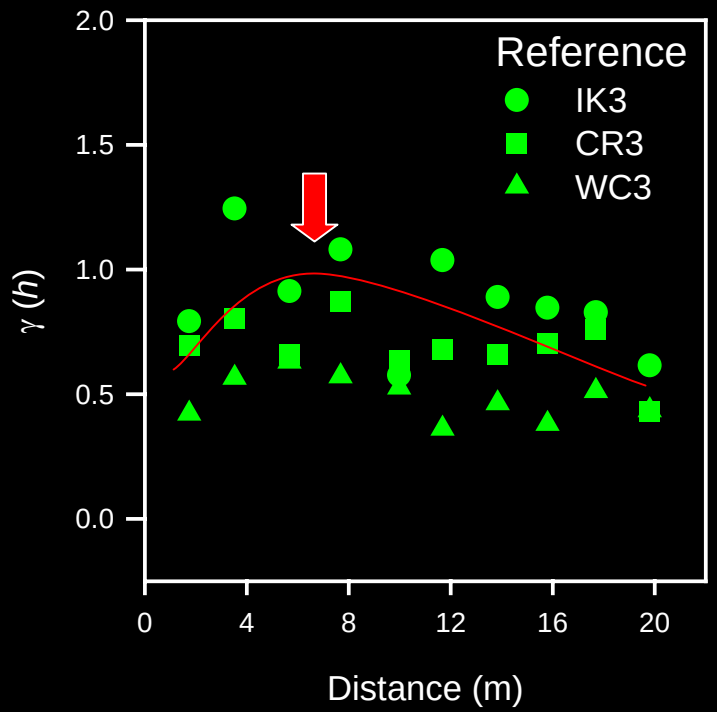

Potassium (mg/g)
Pasturing (25.5)
Logging (14.0)
Reference (11.1)
% Variance
100
80
60
40
20
0
Between-site
Within-site
Within-plot
Scale of Measurement

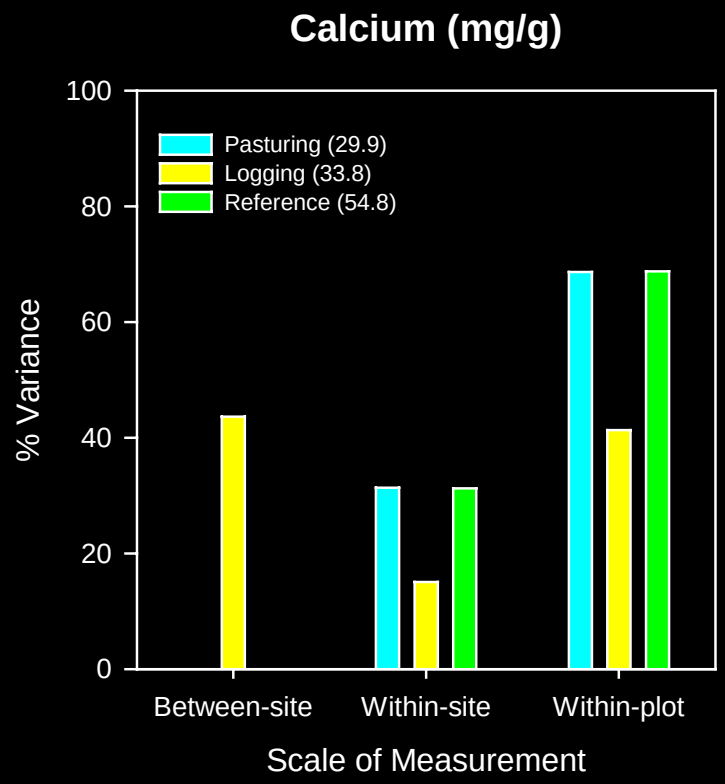

Pasturing
BF1
SB1
PA1
γ (h)
2.0
1.5
1.0
0.5
0.0
0
4
8
12
16
20

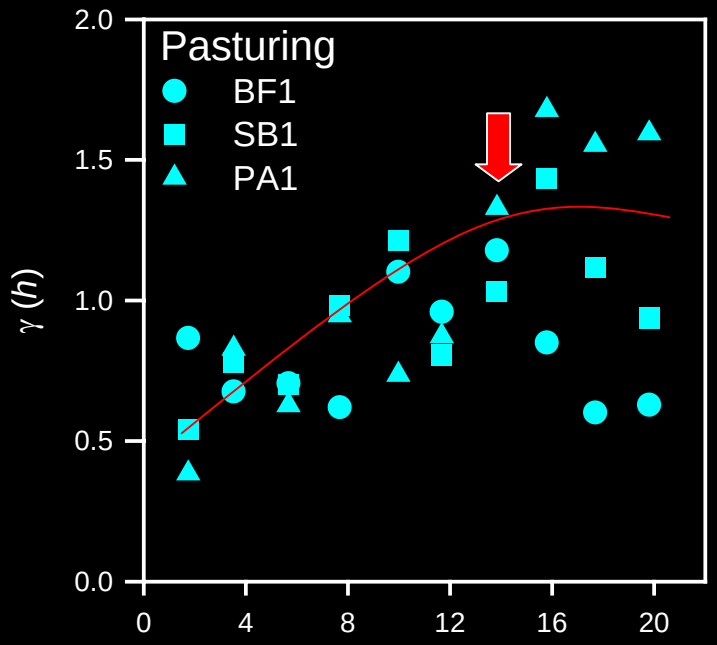

Reference
IK3
CR3
WC3
γ (h)
2.0
1.5
1.0
0.5
0.0
0
4
8
12
16
20
Distance (m)

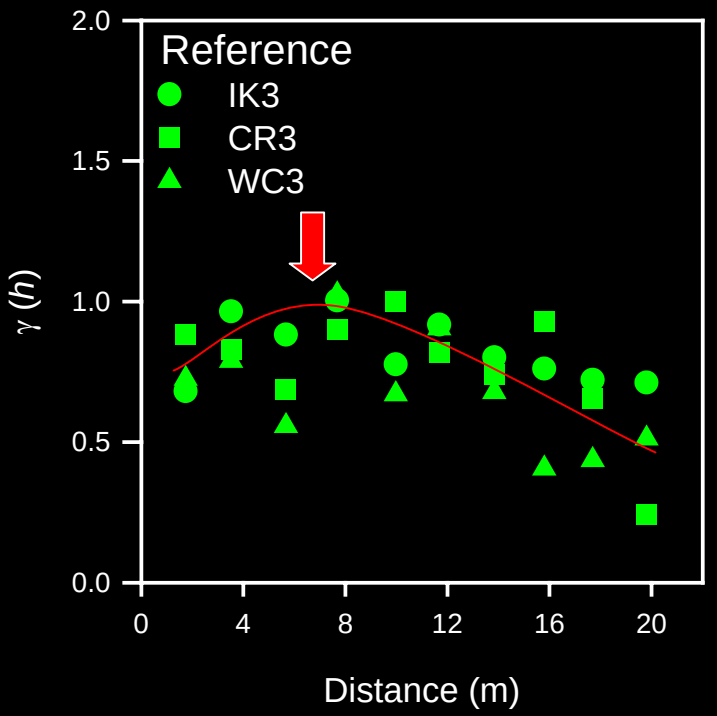

Magnesium (mg/g)
100
80
60
40
20
0
Pasturing (0.50)
Logging (0.45)
Reference (0.31)
Between-site
Within-site
Within-plot
Scale of Measurement


Pasturing
BF1
SB1
PA1
γ (h)
2.0
1.5
1.0
0.5
0.0
0
4
8
12
16
20


Reference
IK3
CR3
WC3
γ (h)
2.0
1.5
1.0
0.5
0.0
0
4
8
12
16
20
Distance (m)


Calcium (mg/g)
100
80
60
40
20
0
% Variance
Pasturing (29.9)
Logging (33.8)
Reference (54.8)
Between-site
Within-site
Within-plot
Scale of Measurement


Pasturing
BF1
SB1
PA1
2.0
1.5
1.0
0.5
0.0
γ (h)
0
4
8
12
16
20


Reference
IK3
CR3
WC3
2.0
1.5
1.0
0.5
0.0
γ (h)
0
4
8
12
16
20
Distance (m)

# Summary of Results: Variance and Spatial Structure

Pasturing and Logging

- ↓ variability in C, N, Ca

*removal & loss of OM, historic and contemporary litter homogeneity*

- ↑ variability in P, K and Mg

*discrete manure inputs, plant uptake, P immobility*

- fine-scale variability → coarse-scale variability

*disruption of nutrient cycles, differential land use*

- ↑ autocorrelation distance of base cations = homogenization

*reduction in OM inputs, decreased litter diversity*

# Conclusions

Prior land use results in soil nutrient pools that are:

- homogeneous at local scales
- heterogeneous at regional scales

Impacts of prior land use on the distribution of soil nutrient pools:

- persist for at least 60 years
- may not be detected by comparing mean concentration or content

# Implications

Soil Nutrients

Climate

Habitat Availability

**Understory Herbs**

Reproductive Strategy

Dispersal Mode

Competition

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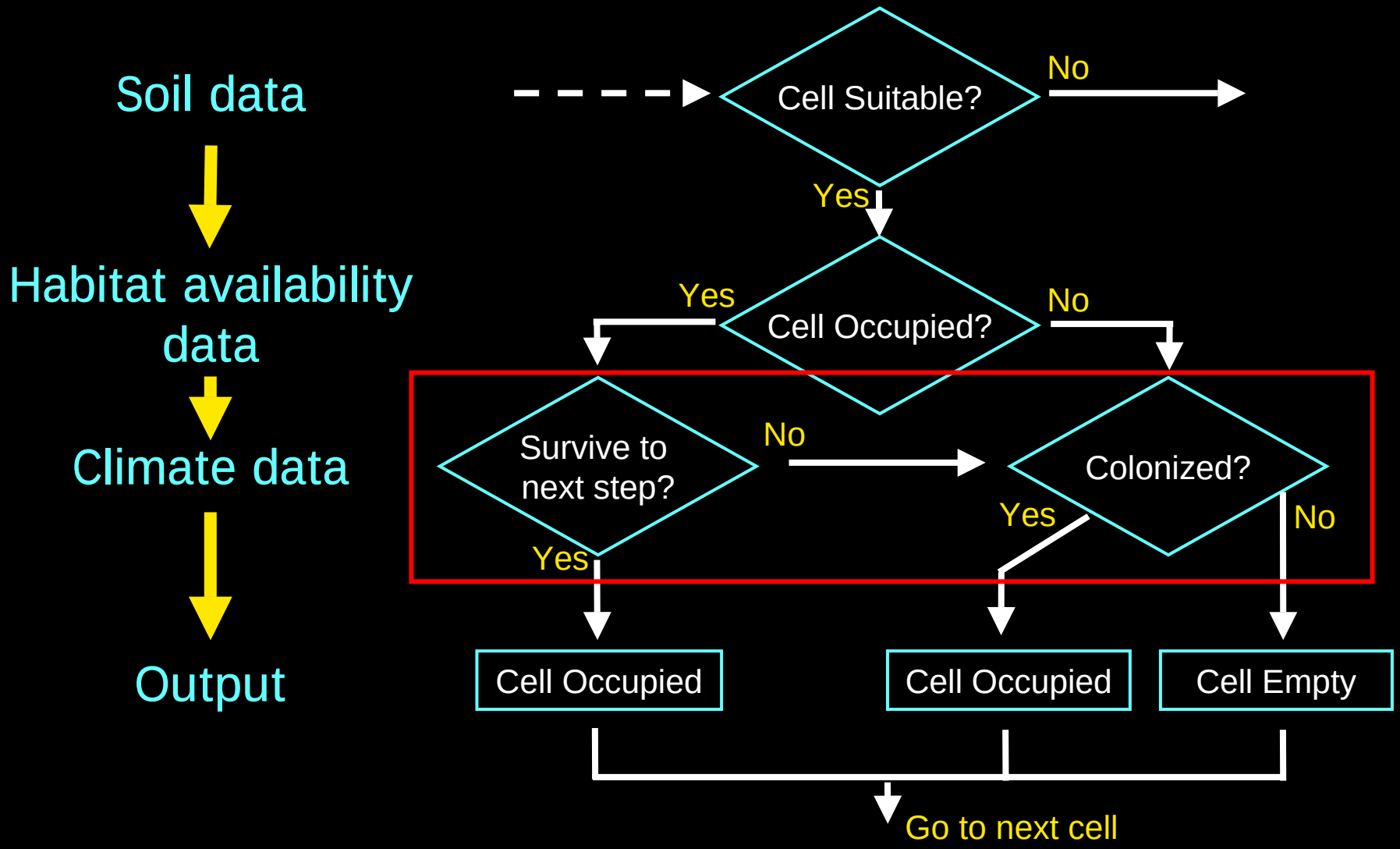
Soil data
Habitat availability data
Climate data
Output
Cell Suitable?
No
Yes
Cell Occupied?
Yes
No
Survive to next step?
No
Colonized?
Yes
No
Yes
Cell Occupied
Cell Occupied
Cell Empty
Go to next cell

# Acknowledgments

Field: *Students from Mars Hill College, especially Dawn Dextraze*

Lab: *Kris Metzger*

Soil methodology and discussion: *Jim Bockheim, John Parsen, Teri Balser, Jennifer Knoepp and Jana Compton*